TIER 3

ENVIRONMENTAL RISK ASSESSMENT

OF A

FORMER MUNICIPAL HISTORIC LANDFILL

AT

RANTAVAN

MULLAGH

CO. CAVAN

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1.0 INTRODUCTION

Traynor Environmental Ltd in conjunction with Cavan County Council has undertaken a Tier 3 Environmental Risk Assessment in relation to Mullagh Historic landfill located at Rantavan, Mullagh, Co. Cavan. The Tier 3 Environmental Risk Assessment was carried out in accordance with requirements of the Waste Management (Certification of historic unlicensed waste disposal and recovery activity) Regulations 2008. Taking cognisance of EPA Code of Practice for Unregulated Waste Disposal Sites a Tier 1 and Tier 2 Environmental Risk Assessment has been carried out previously by Cavan County Council and Traynor Environmental Ltd in 2009 and 2010 respectively. The Tier 3 Risk Assessment must be read in conjunction with Tier 2 Risk Assessment

1.1 SUMMARY OF TIER 2 ENVIRONMENTAL RISK ASSESSMENT

The Tier 2 Risk Assessment process has resulted in the risk rating for the historic landfill remaining as **Moderate Risk.** SPR Linkage number 8 has been proven and thus risk rating assigned accordingly as **Moderate**. As part of the Tier 2 risk assessment an ecological survey was carried out and stated that the landfill site lies approximately 0.80km North of Killyconny Bog SAC 000006. The Tier 1 risk assessment reported that Killyconny bog was >1km from the waste body. As Killyconny Bog is 0.80km from the historical landfill a number of SPR linkages were changed from the Tier 1 Assessment.

- SPR2 has changed from a linkage score of 0.00 to 8.33;
- SPR4 has changed from a linkage score of 0.00 to 6.25; and
- SPR9 has changed from a linkage score of 0.00 to 16.67.

The change in the linkage scores did not change the overall risk rating of the site which remains as **Moderate Risk.**

Table 1: Refinement Of Conceptual Site Model (csm) After Tier 2 Environmental Risk Assessment

Risk Equation	SPR Values	Max Score	Linkages	Normalised Scores (%)
SPR 1 = 1a x (2a + 2b + 2c) x 3e	75	300	Leachate → Surface Water	25.00
SPR 2 = 1a x (2a + 2b + 2c) x 3b	25	300	Leachate → SWDTE	8.33
SPR 3 = 1a x (2a + 2b) x 3a	30	240	Leachate → human Presence	12.5
SPR 4 = 1a x (2a + 2b) x 3b	15	240	Leachate → GWDTE	6.25
SPR 5 = 1a x (2a + 2b) x 3c	15	400	Leachate → Aquifer	3.75
SPR 6 = 1a x (2a + 2b) x 3d	0	560	Leachate → Surface Water	0.00
SPR 7 = 1a x (2a + 2b) x 3e	45	240	Leachate → SWDTE	18.75
SPR 8 = 1a x 2c x 3e	**30**	**60**	**Leachate → Surface Water**	**50.00**
SPR 9 = 1a x 2c x 3b	10	60	Leachate → SWDTE	16.67
SPR 10 = 1b x 2d x 3f	7.5	150	Landfill Gas → Human Presence	5.00
SPR 11 = 1b x 2e x 3f	0	250	Landfill Gas → Human Presence	0.00

Risk Classification	Score Range
High Risk (Class A)	Greater than or equal to 70% for any individual SPR linkage
Moderate Risk (Class B)	Between 40% and 70% for any individual SPR linkage
Low Risk (Class C)	Less than or equal to 40% for any individual SPR linkage

Overall Risk	Moderate Risk (Class B)

1.2 VERTICAL EXTENT OF WASTE ON SITE.

The waste on site is covered by a thin layer of topsoil, which in some areas of the site is underlain by a layer of clay fill which ranged in thickness from 0.2m (TH16) to 1.0m (TH 10). The average thickness of this layer is 0.54m. This clay layer was underlain by waste material which ranged in thickness from 0.4m (TH9) to 2.2m (TH9). The waste is thickest in the centre of the site, with an average thickness across the site of 1.25m. The base of the waste is defined by a layer of peat, which marks the top of the underlying natural subsoils.

1.3 LATERAL EXTENT OF THE WASTE

The North-eastern extent of the landfill was defined by a hedgerow and watercourse/drain which separates the site from the adjacent agricultural land. Wastes were encountered in 18 trial holes (TH1 – TH18), but were not found in the three trial holes (TH19, TH20, TH 21) to the Southeast of the landfill. The waste extends from the local road on the Southwestern boundary to the fence on the North-western boundary. The lateral extent of the waste covers an area of ca 7,650m^2 approximately. It is estimated, that approximately 9,450m^3 of waste is deposited at the site which equates to 18,900 tonnes.

1.4 WASTE CHARACTERISATION

The waste comprised a mix of plastic and glass bottles, occasional empty flattened steel drums, empty plastic drums, concrete pipes, steel, papers, tyres, tyre tubes, wire, end of life vehicles, vehicle parts, municipal waste, timber and trees, all of which were supported by a stony clay matrix. It is assumed that the stony clay was used as cover material when the site was operational, but no discrete layers were noted. No datable materials (newspapers, stationary) which could be used to establish the age of the waste was found. There was evidence of a significant amount of potentially hazardous waste (e.g. oils).

Table 2: Groundwater Level and the Waste Depths in Each Trial Hole Tested On Site

Trial Hole No.	Total Trial Hole Depth (m)	Groundwater Level (m)	Waste start depth (m)	Waste finish depth (m)	Depth of waste (m)
TH1	2.1	1.6	0.6	1.9	1.3
TH2	2.2	1.7	1.0	2.0	1.0
TH3	2.7	1.6	0.5	1.9	1.4
TH4	2.1	1.4	0.5	1.9	1.4
TH5	2.1	1.4	0.5	1.8	1.3
TH6	2.2	1.3	0.5	1.7	1.2
TH7	2.2	1.4	0.8	1.8	1.0
TH8	2.4	1.9	0.6	2.1	1.5
TH9	2.5	2.0	0.4	2.2	1.8
TH10	2.2	1.3	1.0	1.8	0.8
TH11	2.3	1.4	0.7	1.8	1.1
TH12	2.3	1.3	0.5	1.9	1.4
TH13	2.4	1.6	0.5	2.0	1.5
TH14	2.0	1.2	0.3	1.7	1.4
TH15	1.8	1.1	0.2	1.5	1.3
TH16	1.6	0.7	0.2	1.3	1.1
TH17	2.4	1.2	0.6	1.6	1.0
TH18	1.5	0.6	0.3	1.2	0.9
TH19	2.0	1.6	-	-	-
TH20	2.1	1.8	-	-	-
TH21	2.4	1.9	-	-	-

Drawing No 10-198-010 shows locations of all trial holes on site. Please see Appendix A of the Tier 3 assessment.

2.0 GENERIC QUANTITATIVE RISK ASSESSMENT (GQRA)

2.1 CONTEXT AND OBJECTIVES

GQRA involves the comparison of contaminant concentrations measured in soil, water or gas at a site with generic assessment criteria. Generic assessment criteria are typically conservative to ensure that they are applicable to the majority of sites and normally apply to only a limited number of pollutant linkages.

A Quantitative Risk Assessment has been carried out which includes the development of a conceptual site model, which describes the types and locations of potential contamination sources, the identification of potential receptors and the identification of potential transport/migration pathways. For a pollutant linkage to be identified a connection between all three elements (source-pathway-receptor) was required.

Known concentrations of various contaminants, obtained as a result of an intrusive investigation, are evaluated for their significance as a contamination source by comparison with Generic Assessment Criteria (GAC). Previous intrusive investigations on-site were carried out in October 2010.

The significance of the risks presented by the site are assessed in relation to the proposed end-use as a wildlife habitat. The following assessment should not be read independently of other sections of the report and the Tier 2 Assessment Report. The GQRA uses chemical testing and other data used previously in the Tier 2 Assessment Report.

A representation of the conceptual site model is presented in Drawing No. 10-198-017 which is located in Appendix A.

Results for Soil, Groundwater, Surface water and Gas monitoring points are compared to Dutch Intervention Values. Dutch Standards are environmental pollutant reference and intervention values. The soil remediation intervention values indicate when the functional properties of the soil for humans, plants and animals is seriously impaired or threatened. They are representative of the level of contamination above which a serious case of soil contamination is deemed to exist. The results were not screened against human health assessment criteria as the site is going to be closed and fenced off by Cavan County Council and not used for development.

2.2 SOIL ANALYSIS RESULTS

A total of 4 no soil samples were taken for analysis. The soil samples were taken from trial holes TH11, TH13, TH18 & TH21 (Baseline) and analysed for the following:

- Inorganics;
- Metals;
- Mineral Oil / Oils & Greases;
- Extractable Petroleum Hydrocarbons (EPH);
- Polyaromatic Hydrocarbons (PAHs);
- Volatile Organic Compounds (VOCs);

TH11 exceeded the Dutch Intervention value for Polyaromatic Hydrocarbons Total USEPA 16 PAH. TH18 exceeded the Dutch intervention values for Copper and Zinc.

Table 3: Soil Sample Results Which Exceeded The Assessment Criteria (Dutch Intervention Values).

Parameter	Trial Holes Sampled				Dutch Intervention Values Intervention Value (mg/kg)
	TH11	TH13	TH18	TH21	
Copper	-	-	681	-	190
Zinc	-	-	915	-	720
Polyaromatic hydrocarbons, Total USEPA 16	79.1	-	-	-	40

No exceedances of the Dutch intervention values for TH13 and TH21 were noted. (Refer to results in Tier 2 Risk Assessment Report)

2.3 GROUNDWATER (TRIAL PITS) RESULTS

Mineral oil >C10 C40 (aq) exceeded the Dutch Intervention value for TH3, TH6, TH8, TH11, TH13 and TH18.

EPH Range >C10 - C40 (aq) exceeded the Dutch intervention value for TH6 and TH11. Fluoranthene (aq) exceeded the Dutch intervention value for TH8 and TH11. Anthracene, Chrysene, Benzo (a) anthracene (aq) exceeded the Dutch intervention value in TH11. Benzo (b) Fluoranthene (aq) exceeded the Dutch intervention values for TH8 and TH11. Benzo (a) pyrene (aq) exceeded the Dutch intervention values in TH6, TH8 and TH11. Benzo(g,h,i) perylene exceeded the dutch intervention values for TH6, TH8 and TH11. Indeno (1,2,3-cd) pyrene (aq) exceeded dutch intervention value for TH6, TH8, TH11. The analytical data suggests that the waste material on site has not had a negative impact on the groundwater down gradient of the site as shown in TH21. (Refer to Tier 2 Risk Assessment Report)

Table 4: Groundwater Monitoring Trial Hole Samples (mg/l) Results (within the site) Which Exceeded The Dutch Intervention Values

Parameter	TH3	TH6	TH8	TH11	TH13	TH18	Dutch Intervention Values Intervention Value (mg/l)
Mineral oil >C10 C40 (aq)	0.923	1.740	0.0953	3.660	0.795	0.800	**0.06**
EPH Range >C10 - C40 (aq)	-	2.490	-	2.860		-	**2.00**
Fluoranthene (aq)	-	-	0.000173	0.00128	-	-	**0.0001**
Anthracene (aq)	-	-	-	0.000228	-	-	**0.00005**
Chrysene (aq)	-	-	-	0.000892	-	-	**0.0002**
Benzo(a)anthracene (aq)	-	-	-	0.000694	-	-	**0.0005**
Benzo(b)fluoranthene (aq)	-	-	0.00015	0.000944	-	-	**0.00005**
Benzo(a)pyrene (aq)	-	0.000113	0.000186	0.00102	-	-	**0.00005**
Benzo(g,h,i)perylene (aq)	-	0.000053	0.000134	0.000968	-	-	**0.00005**
Indeno(1,2,3-cd)pyrene (aq)	-	0.000057	0.000127	0.000817	-	-	**0.00005**

Previous investigation contamination test results are presented in Tier 2 Assessment. (Refer to Tier 2 Risk Assessment Report)

2.4 SURFACE WATER MONITORING

4 No. surface water samples were analysed for a range of organic and inorganic parameters that included pH, electrical conductivity, dissolved oxygen, ammonia, nitrite, nitrate, orthophosphate, potassium, sodium, chloride, sulphate, heavy metals to include(arsenic, antimony, barium, cadmium, chromium, copper, Fluoride, mercury, manganese, molybdenum, nickel, lead, selenium and zinc), cyanide, Volatile Organic Compounds (VOC), Total Petroleum Hydrocarbons (Diesel Range Organics(DRO), MTBE, Petrol Range Organics (PRO)), Phenols, total pesticides.

Table 5: Surface Water Monitoring Parameters Which Exceeded The Environmental Quality Standards (EQS).

Parameter	Sw2	Sw3	Environmental Quality Standard (EQS)
pH	6.42	-	6.5 – 8.5
Manganese	0.484 mg/l	2.69mg/l	0.30mg/l
Chromium	-	0.0327	0.03mg/l

Previous investigation contamination test results are presented in Tier 2 Assessment. (Refer to Tier 2 Risk Assessment Report)

Manganese exceeded the EQS for surface water monitoring locations SW-2 and SW-3 with results of 0.484mg/l and 2.690mg/l respectively. Chromium exceeded the EQS for surface water monitoring location SW-3. Cresol was detected in Sw2 at a low level. All other parameters analysed were below their respective EQS.

2.5 LANDFILL GAS MONITORING

8 No. trial holes were monitored for landfill gas. After monitoring the 8 No. trial holes it was decided to cease gas monitoring due to the low levels of gas detected in the first 8 trial holes. The gas monitoring programme included the measurement of methane and carbon dioxide. The meter was calibrated before use. Based on the negligible landfill gas levels detected Traynor Environmental Ltd considers that the risk posed by landfill gas to be insignificant.

Table 6: Gas Monitoring At Mullagh Historic Landfill

Parameter	Result (%)				Comments
	Methane (CH_4)	Carbon Dioxide (CO_2)	Oxygen (O_2)	Nitrogen Dioxide (NO_2)	
GR1	0.01	0.01	21.6	78.2	No notable odour detected
GR2	0.01	ND*	21.5	78.3	Oil odour detected
GR3	ND*	ND*	21.4	78.5	Burnt / Oily odour detected
GR4	0.01	0.01	21.4	78.4	Burnt odour detected
GR5	0.01	ND*	21.3	78.5	Oily odour detected
GR6	0.01	ND*	21.3	78.5	Burnt odour detected
GR7	ND*	ND*	21.4	78.5	Oil odour detected
GR8	0.01	0.01	21.3	78.5	Strong oil odour detected

* ND - Not Detected

3.0 PROPOSED OPTION A

3.1 GENERAL OBJECTIVES

The waste on site is covered by a thin layer of topsoil, which in some areas of the site is underlain by a layer of clay fill which ranged in thickness from 0.2m (TH16) to 1.0m (TH 10). The average thickness of this layer is 0.54m. This Clay layer was underlain by waste material which ranged in thickness from 0.4m (TH9) to 2.2m (TH9). The waste is thickest in the centre of the site, with an average thickness across the site of 1.25m. The base of the waste is defined by a layer of peat, which marks the top of the underlying natural subsoils.

The remediation options will have the following objectives:-

- The primary objective is to break pollution linkage outlined in SPR Linkage No. 8;
- To reduce and /or eliminate any pollution risk associated with the site;
- Minimise risk to nearby watercourses/reduce impact;
- To reduce ground water contamination, the site has a shallow groundwater flow due to the presence of impermeable clay underlying the site.
- To separate ground water from surface water as much as practicably possible (by preventing leachate from seeping out through the sides of the landfill);
- To improve overall appearance of the landfill;
- To provide suitable conditions for plant and other vegetation growth.

3.2 PROPOSED REMEDIATION MEASURES

The proposed measures below have been considered in the context of Option A.

- 3.2.1 - Removal of Hazardous Wastes;
- 3.2.2 - Remediation/Removal of Contaminated Soil;
- 3.2.3 - Remediation/Removal of Contaminated Ground water;
- 3.2.4 - Remediation/Removal of Contaminated soil from base of adjacent watercourse/drain.
- 3.2.5 – Chemical and Biological Monitoring
- 3.2.6 – Capping of Mullagh Landfill
- 3.2.7 - Surface water Control and Management

3.2.1 REMOVAL OF HAZARDOUS WASTE

The Tier 2 Environmental Risk Assessment involved the excavation of trial holes within the waste body and outside the waste body. The landfill was divided into equal sections in order to obtain a representative assessment of same during the excavation works. A total of 21 trial holes were excavated on site with 18 excavated within the landfill footprint itself. Another 3 trial holes were excavated outside of the main landfill body for the purpose of providing baseline assessment and data. All 21 trial holes excavated on site were visually assessed by an experienced employee of the Waste Management Section of Cavan County Council and an experienced employee of Traynor Environmental Ltd. Full details of all 21 trial holes can be found in Appendix A of the Tier 2 Environmental Risk Assessment - Trial Hole Logs. The logs shows photographic evidence of the waste present, a profile of waste depths in each hole and a list of European Waste Catalogue (EWC) Codes of all waste encountered.

During the excavation works groundwater samples were taken and analysed as per the EPA Landfill monitoring requirements. Hazardous waste was identified in trial holes 3, 6, 8, 11, 13 and 18 during investigation works. A full listing of parameters sampled and associated results can be found in Appendix C of the Tier 2 Environmental Risk Assessment – Alcontrol Laboratories Certificate of Analysis. Sample results for these trial holes exceeded Dutch Intervention Values for the following parameters:

- Mineral oil >C10 C40 (aq)
- EPH Range >C10 - C40 (aq)
- Fluoranthene (aq)
- Anthracene (aq)
- Chrysene (aq)
- Benzo(a)anthracene (aq)
- Benzo(b)fluoranthene (aq)
- Benzo(a)pyrene (aq)
- Benzo(g,h,i)perylene (aq)
- Indeno(1,2,3-cd)pyrene (aq)

Table 4 in Section 2.3 of the above document details levels of exceedances for samples taken in trial holes 3, 6, 8, 11, 13 and 18. Soil samples were also taken in the vicinity of these trial holes and showed exceedances of the Dutch Intervention values. For example TH11 exceeded the Dutch Intervention value for Polyaromatic Hydrocarbons Total USEPA 16 PAH while TH18 exceeded the Dutch intervention values for Copper and Zinc.

From the analysis of sample results obtained, the waste/clay mixture in areas around trial holes 3, 6, 8, 11, 13 and 18 have been deemed hazardous. For this reason it is proposed to concentrate on these locations and remove the hazardous waste/clay mixture. Hazardous wastes (engine blocks, oil filters, barrels containing chemical waste) will be prioritised with regard to excavation and removed from the waste body and sent for disposal using a hazardous waste company. The removal of the waste will prevent the interaction of groundwater with hazardous waste and avoid any future mobilisation of contaminants within the waste body.

3.2.1.1 Impact of Remediation Measures

The removal of the hazardous waste from the historic landfill is ultimately removing the source of contamination from the site and thus breaking the source-pathway-receptor linkage as highlighted in the Tier 2 Environmental Risk Assessment. However the removal of the hazardous waste from the site poses a number of potential risks. The physical act of removing the waste could potentially mobilise contaminants which are dormant within the site and aid their migration to the nearby watercourse/drain. Furthermore, the removal of the hazardous waste could puncture the peat layer underlying the site and result in the vertical migration of contaminants to groundwater. The risk to workers and nearby residents must also be considered given the contaminants identified. Currently the hazardous waste fraction is bound within the landfill matrix and covered with a thin capping layer and therefore contaminants within same are considered relatively immobile. The removal of the hazardous waste could create hazardous airborne particulates in the vicinity of the work area. Workers immediate to the work area and residents downwind of the site could be negatively impacted by the dig-out and removal of the hazardous waste.

3.2.1.2 Alternative Considered

The waste around trial holes 3, 6, 8, 11, 13 and 18 has been deemed hazardous. Sample results for groundwater and soil coupled with on site observations confirm the presence of hazardous waste. Leaving the waste in-situ and monitoring was not considered a feasible option given the contaminants identified in the Tier 2 Environmental Risk Assessment. (Note: - Dutch Intervention Values were exceeded in the aforementioned trial holes).

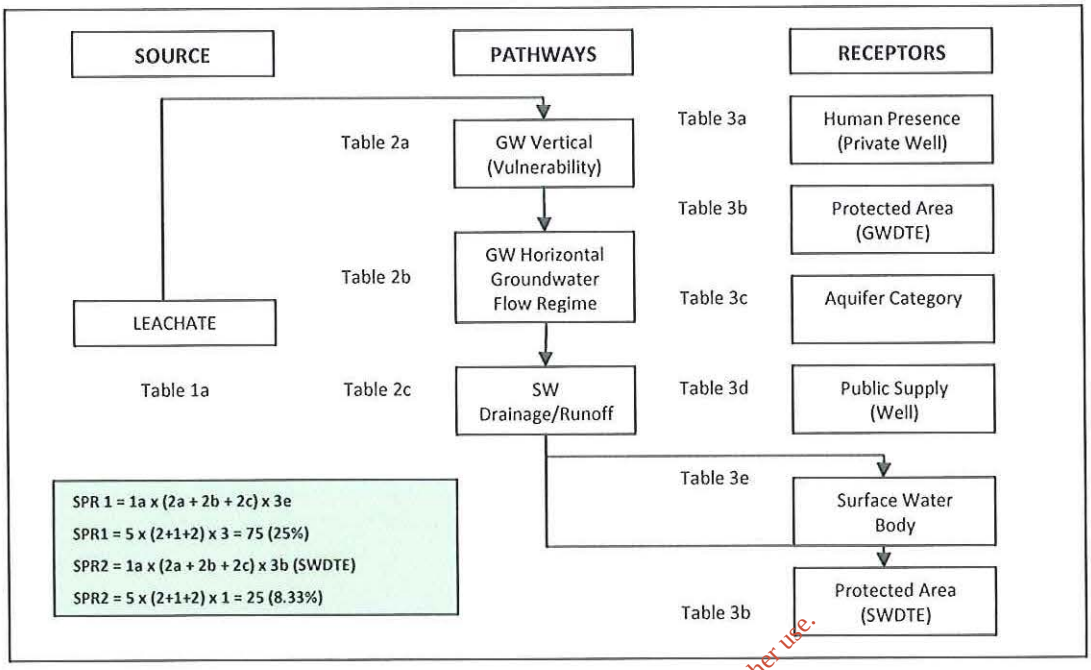
3.2.1.3 Recommended Remediation Measure

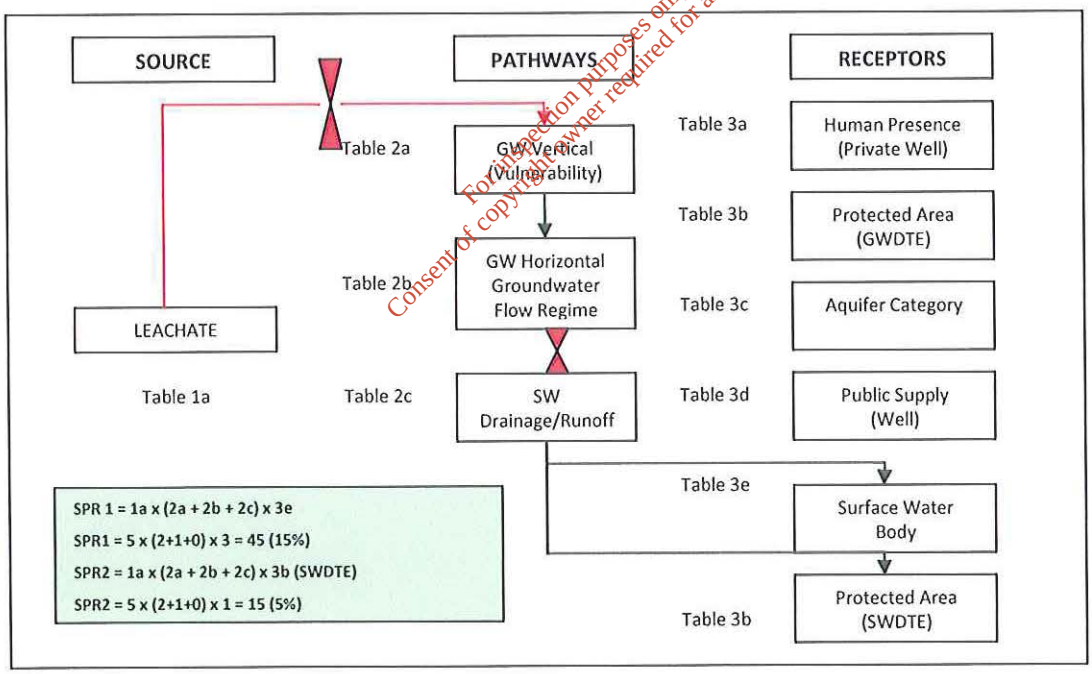
The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd recommends the complete dig-out and removal of all hazardous waste in and around trial holes 3, 6, 8, 11, 13 and 18 on site. The guesstimated tonnage for dig-out and removal is 3,360. The said tonnage includes the hazardous waste and the supporting soil/clay matrix around the hazardous waste.

3.2.1.4 SPR Linkage Diagram

See diagram 1 showing the SPR Linkage prior and post remediation and highlighting the break in the linkage by the removal of the hazardous waste.

Diagram 1 – SPR Linkage Diagram Showing the break in the linkage before and after the removal of the hazardous waste.





3.2.1.5 Timescale for Completion of Works

The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd would guesstimate a timeframe of 2-3 months for the dig-out and removal of hazardous waste in and around the aforementioned trial holes. The said timescale for the removal of the hazardous waste is dependent on resources available, weather conditions and no unforeseen problems during the excavation works e.g. greater quantities of hazardous waste than first estimated.

3.2.1.6 Evaluation of Works

Physical, chemical and biological monitoring of surface water and groundwater would be undertaken periodically both during and after the excavation of the hazardous waste to ensure the containment of same. The testing will ensure that no contaminants migrate from the excavation areas. Trigger levels for both surface water and groundwater will be set (based on baseline data prior to remediation works) thus preventing any deterioration in water quality.

3.2.2 REMEDIATION/REMOVAL OF CONTAMINATED SOIL

Soil samples were taken during the Tier 2 Environmental Risk Assessment and analysed as per the EPA Landfill monitoring requirements. Soil samples taken from trial holes 11, 13 and 18 were deemed hazardous with Dutch Reference and Intervention values exceeded for the said trial holes. A full listing of parameters sampled and associated results can be found in Appendix C of the Tier 2 Environmental Risk Assessment – Alcontrol Laboratories Certificate of Analysis. The following parameters exceeded the Dutch Reference and Intervention values for the aforesaid trial holes:

- Copper
- Lead
- Nickel
- Zinc
- PAH Total US EPA 16

3.2.2.1 Impact of Remediation Measures

The removal of the contaminated soil from the historic landfill will remove the source of contamination from the site and thus break the source-pathway-receptor linkage as highlighted in the Tier 2 Environmental Risk Assessment. The removal of the contaminated soil around trial holes 11, 13 and 18 will be carried out in conjunction with the removal of the hazardous waste. Please note that trial holes 3, 6 and 8 contained hazardous waste as detailed earlier. It is probable that the soil surrounding these trial holes is contaminated and will also require removal and disposal. The removal of contaminated soil would pose similar risks as identified in the removal of the hazardous waste. The digging and disturbance of the soil could potentially mobilise contaminants and aid their migration to the nearby watercourse/drain. Furthermore, the removal of the contaminated soil could puncture the peat layer underlying the site and result in the vertical migration of contaminants to groundwater. As stated in the Section 3.2.1.1 with regard to the removal of hazardous waste, the risk to workers and nearby residents must be considered given the contaminants identified. The disturbance of the contaminated soil could create hazardous airborne particulates and impact negatively on workers and nearby residents.

3.2.2.2 Alternative Considered

Soil can be excavated from the ground and be either treated or disposed

Contaminated soil containing hazardous waste from trial holes 3, 6, 8, 11, 13 and 18 on the site (please see Trial hole Logs in Appendix A of Tier 2) could be removed and sent for disposal using an appropriately licensed hazardous waste disposal company. It is calculated based on the Tier 2 Environmental Risk Assessment that approximately 3,360 tonnes of contaminated soil which includes waste may require excavation and disposal using a hazardous waste contractor. Please refer to drawing No. 10.198.021 in Appendix A which details key areas of contaminated soil which should be considered for removal.

Soil can be left in the ground and treated in-situ

The bioremediation of contaminated landfill soil in-situ is deemed impracticable. Following consultation with a specialist company in the field of bioremediation (Raw Group, Unit 4 Sligo Enterprise Centre, Strandhill, Co. Sligo) the process of bioremediation maybe unsuccessful. Furthermore the soil may still need to be sent for disposal after treatment. The cost to treat this type of contaminated soil in-situ is approximately €100 per tonne.

Soil can be left in the ground and contained to prevent the contamination from mobilising and interacting with uncontaminated areas of the site

Contaminated soil could be covered with a plastic cover and/or capping layer to prevent the interaction between rain water and contaminated soil. This should prevent the ingress of precipitation and the subsequent leaching and mobilisation of contaminates entrained within the soil. However, the waste body would require an overall plastic cover and/or capping layer to prevent the ingress of precipitation. It must also be stated that lateral shallow groundwater flow would still persist on the site.

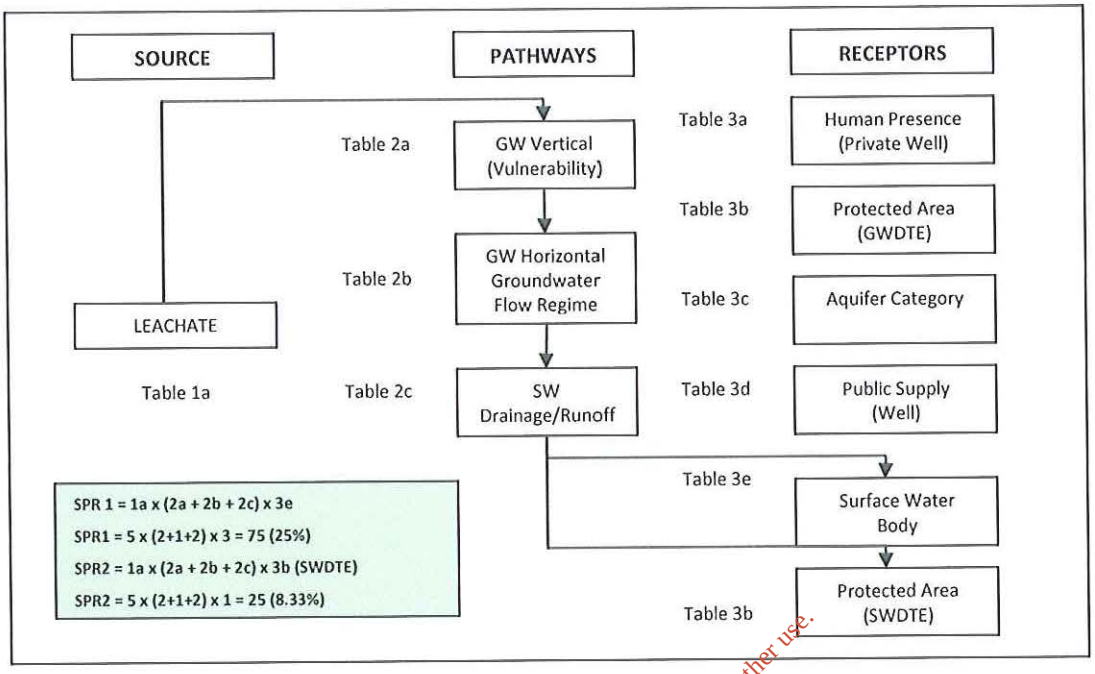
3.2.2.3 Recommended Remediation Measure

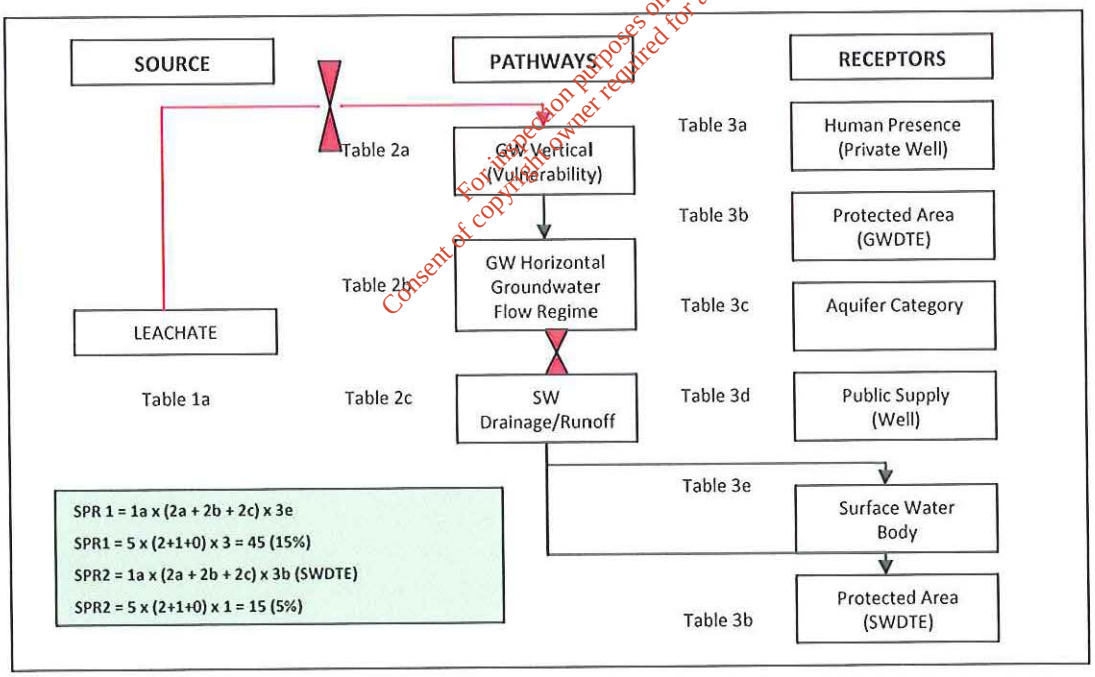
The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd recommends the complete dig-out and removal of contaminated soil around trial holes 3, 6, 8, 11, 13 and 18. The said soil will be sent for disposal using an authorised waste contractor. The works will be carried out in conjunction with the dig-out and removal of the hazardous waste. The guesstimate tonnage of soil for dig-out and removal would be similar to the hazardous waste tonnage quoted in Section 3.2.1.3. The hazardous waste and soil is inherently intertwined and thus the tonnage for dig-out and removal is guesstimated at 3,360.

3.2.2.4 SPR Linkage Diagram

See diagram 2 showing the SPR Linkage prior and post remediation and highlighting the break in the linkage by the removal of the hazardous soil.

Diagram 2 – SPR Linkage Diagram showing the break in the linkage before and after the removal of the hazardous soil





3.2.2.5 Timescale for Completion of Works

The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd would guesstimate a timeframe of 2-3 months for the dig-out and removal of contaminated soil in and around the aforementioned trial holes. As stated previously the dig-out and removal of the contaminated soil can be carried out in conjunction with the removal of the hazardous waste. The said timescale for the removal of the contaminated soil is dependent on resources available, weather conditions and no unforeseen problems during the excavation works e.g. greater quantities of contaminated soil than first estimated.

3.2.2.6 Evaluation of Works

Soil removed during the dig-out phase would require periodic testing for parameters identified in the Tier 2 Environmental Risk Assessment. This will ensure the removal and disposal of only contaminated soil and minimise the cost associated with the disposal of same.

Table 7: Table showing approximate amounts of soil around each Trial Hole to be removed off site

Trial Hole No.	Depth of waste (m)	Zone Area (m^2)	Waste Volume (m^3)	Total Waste Volume Tonnes	Non Contaminated Tonnage Approx	Contaminated Tonnage Approx
TH1	1.3	550	715	1430	1430	-
TH2	1.0	500	500	1000	1000	-
TH3	1.4	450	630	1260	1260	-
TH4	1.4	500	700	1400	1400	-
TH5	1.3	500	650	1300	1300	-
TH6	1.2	250	300	600	-	600
TH7	1.0	550	550	1100	1100	-
TH8	1.5	300	450	900	-	900
TH9	1.8	400	720	1440	1440	-
TH10	0.8	450	360	720	720	-
TH11	1.1	300	330	660	-	660
TH12	1.4	450	630	1260	1260	-
TH13	1.5	250	375	750	-	750
TH14	1.4	450	630	1260	1260	-
TH15	1.3	450	585	1170	1170	-
TH16	1.1	500	550	1100	1100	-
TH17	1.0	550	550	1100	1100	-
TH18	0.9	250	225	450	-	450
TH19	-	-	-	-	-	-
TH20	-	-	-	-	-	-
TH21	-	-	-	-	-	-
Total Tonnages					15,540	3,360

3.2.3 REMEDIATION/REMOVAL OF CONTAMINATED GROUNDWATER

Groundwater samples taken during the excavation of the trial pits were analysed as per the EPA Landfill monitoring requirements. These samples would represent shallow groundwater flow and the interaction of same with hazardous waste and contaminated soil within the landfill. The underlying peat layer would prevent the vertical migration of contaminates and thus lateral flow would be the predominant pathway. Groundwater samples taken from trial holes 3, 6, 8, 11, 13 and 18 were deemed hazardous with exceedances for the following parameters:-

- Mineral oil >C10 C40 (aq)
- EPH Range >C10 - C40 (aq)
- Fluoranthene (aq)
- Anthracene (aq)
- Chrysene (aq)
- Benzo(a)anthracene (aq)
- Benzo(b)fluoranthene (aq)
- Benzo(a)pyrene (aq)
- Benzo(g,h,i)perylene (aq)
- Indeno(1,2,3-cd)pyrene (aq)

3.2.3.1 Impact of Remediation Measures

Shallow groundwater interacting with hazardous waste and contaminated soil within the landfill body would be deemed hazardous. The highlighted exceedances would be indicative of this fact and therefore contaminated groundwater would require remediation and/or removal. The pump-out and removal of the contaminated groundwater would remove the source of contamination and thus break the source-pathway-receptor linkage. However, the pumping of shallow groundwater could lead to greater volumes of contaminated groundwater. The physical act of pumping could create a cone of depression around the excavation areas and result in the ingress of clean uncontaminated groundwater.

3.2.3.2 Alternative Considered

Groundwater which is deemed to be hazardous in terms of chemical and oil contamination could be removed by vacuum tanker and sent for disposal using a hazardous waste contractor.

Trial holes with known contamination could be excavated with the resultant groundwater removed by vacuum tanker and sent for hazardous waste disposal. The groundwater around trial holes 3, 6, 8, 11, 13 and 18 would be deemed hazardous and could be suitable for removal and disposal using the aforementioned method. However, the pumping of groundwater could create a cone of depression around the trial hole and lead to even greater volumes of contaminated groundwater requiring removal and disposal.

Groundwater which is deemed to have only oil contamination could be removed by vacuum tanker and passed through a full oil retention separator with the resultant oil sent for hazardous waste disposal. The water arising from the separator could be discharged to the watercourse/drain providing a full schedule of testing is carried out prior to discharge.

Trial holes with only oil contaminated groundwater could be removed using a vacuum tanker and passed through a full Class 1 oil/water retention separator. The resultant water could be discharged to the nearby watercourse/drain but would be dependent on a full schedule of testing prior to discharging. All trial holes with the exception of TH 19, 20 & 21 had oil contamination. The application of this method would be dependent on oil contamination only and would not apply if chemical contamination was detected.

Contaminated groundwater could be left in the ground and contained to prevent leaching and the mobilisation of contaminates.

The containment of groundwater could be achieved by the installation of a plastic cover and/or capping layer thus minimising the interaction between the waste body and precipitation. The landfill is underlain by a layer of impermeable peat thus limiting the vertical movement of contaminants. However, the lateral movement of shallow groundwater would continue and facilitate the migration of contaminants through the waste body.

3.2.3.3 Recommended Remediation Measure

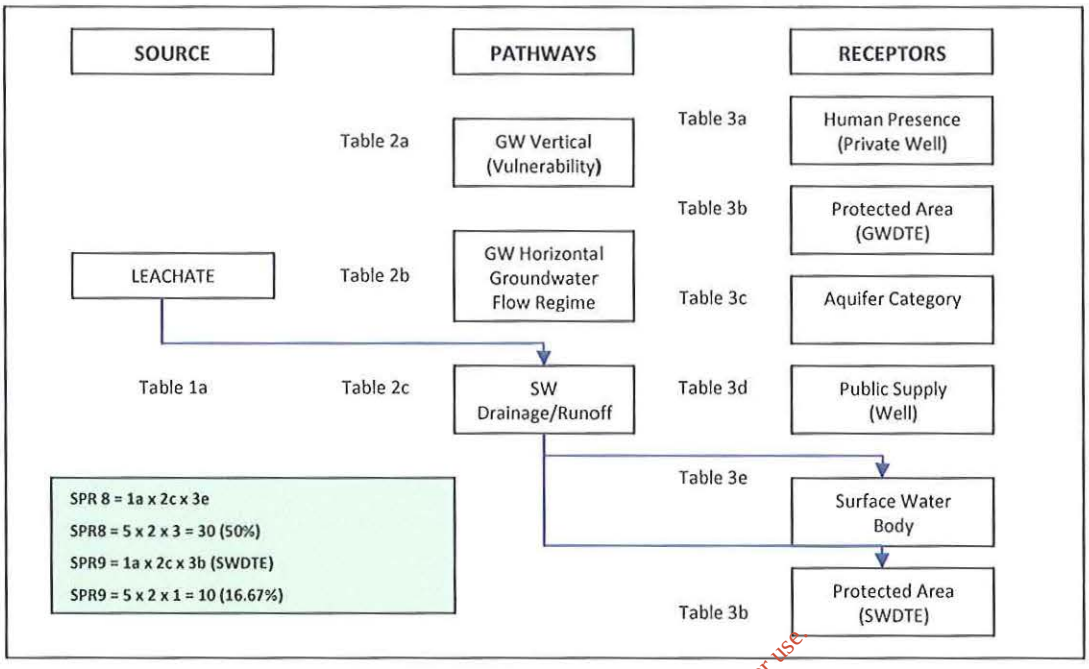
The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd recommends the pump-out and disposal of contaminated groundwater. The contaminated groundwater would be removed using a vacuum tanker with same sent for disposal using a hazardous waste disposal contractor. The said works would be carried out in conjunction with the dig-out and removal of the hazardous waste and contaminated soil. It is impossible to guesstimate the volume of contaminated groundwater requiring removal and disposal as the quantity will depend on site conditions and other uncontrollable variables e.g. weather conditions. Trial holes with only oil contamination will be passed through a Class 1 oil/water separator. The oily content of the separator would be sent for disposal using a hazardous waste contractor. The resultant water would be discharged to the nearby watercourse/drain but would be dependent on a full schedule of testing prior to discharging.

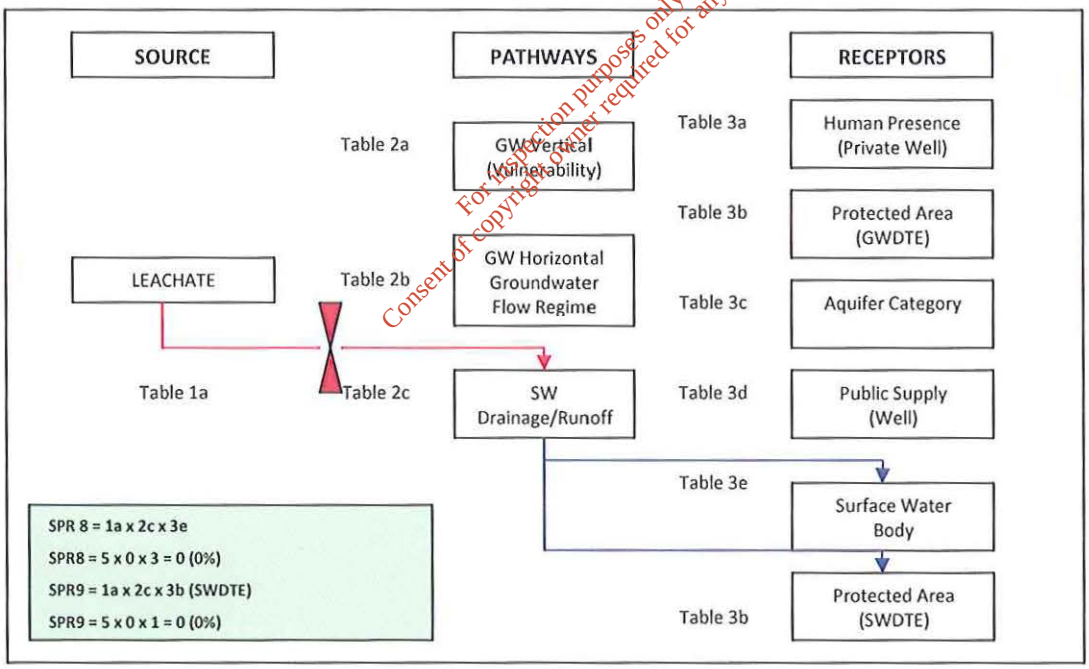
The infiltration of clean uncontaminated surface and groundwater from outside the landfill footprint is a cause for concern. The installation of an interceptor drain upslope of the site will divert surface water away from the landfill. Furthermore, shallow groundwater flow will also be diverted away from the landfill minimising the ingress of clean uncontaminated groundwater during the pump-out phase. This should be carried out prior to the commencement of any remediation works.

3.2.3.4 SPR Linkage Diagram

See diagram 3 showing the SPR Linkage prior and post remediation and highlighting the break in the linkage by the removal of the contaminated groundwater.

Diagram 3 – SPR Linkage Diagram Showing the break in the linkage by the removal of the contaminated groundwater





3.2.3.5 Timescale for Completion of Works

The estimated time frame for the completion of the pump-out and removal of the contaminated groundwater is somewhat difficult to guesstimate. The removal and disposal of the hazardous waste and soil is guesstimated at 2-3 months and the pump-out phase will probably mirror this timescale. Periodic testing of the pump-out water would be required and the level of contamination contained within same will ultimately determine the pump-out required. It is anticipated that the pump-out would be carried out intermittently in order to reduce the high water levels in certain areas of the landfill body. The timescale would also be dependent on resources available, weather conditions and no unforeseen problems during the pump-out phase e.g. greater volumes of contaminated pump-out water than first anticipated.

3.2.3.6 Evaluation of Works

During the works, pump-out water would require periodic testing for parameters identified in the Tier 2 Environmental Risk Assessment. This will enable an assessment of the contamination level within the pump-out water and minimise the amount of water requiring removal and disposal by a specialist contactor. Coupled with this periodic testing; nearby watercourses and drainage channels would be tested for a range of indicator parameters to insure no adverse impacts on nearby receptors. Trigger levels for both surface water and groundwater will be set (based on baseline data prior to remediation works) thus preventing any deterioration in water quality.

3.2.4 REMEDIATION/REMOVAL OF BASE OF WATERCOURSE/DRAIN

A large amount of contaminants are possibly bound within the substrate at the base of the watercourse/drain that is immediate to the landfill. Chemical analysis of the surface water indicated elevated levels of Manganese and Chromium only. However, the biological analysis indicated long term pollution effects on the watercourse from the waste body and this was validated by the Q2 biological assessment rating assigned along the interaction zone. Contaminants within the substrate could be mobilised intermittently with rainfall events or disturbance of the substrate and thus impact negatively on water quality.

3.2.4.1 Impact of Remediation Measures

The removal of the substrate at the base of the watercourse/drain would remove the source of contamination in the watercourse/drain. The excavation of the substrate could possibly result in the release of contaminants bound within the substrate and thus have an adverse impact on water quality downstream of the site.

3.2.4.2 Alternative Considered

Watercourse/drain could be cleaned and disposed of accordingly

The substrate at the base of the watercourse could be excavated and disposed of by a hazardous waste disposal company. This would be subject to appropriate testing for contaminants bound within the substrate prior to any works taking place. If the substrate proved negative for the presence of contamination excavation works would still be carried out. The works would enhance drainage and break the interaction interface between the landfill and the watercourse/drain. The resultant water arising from the works would pass through a full class 1 oil/water retention separator in the event of any oily residues and be discharged

to nearby watercourse. The discharge of the water would be dependent on a full schedule of testing being carried out as per the EPA landfill monitoring requirements.

Watercourse/drain could be left undisturbed and contained to prevent the mobilisation of possible contaminants

The watercourse/drain could be left undisturbed thus minimising the mobilisation of contaminates within the substrate. However, the intermittent release of contaminates may still persist and lead to long term pollution effects especially within the watercourse/drain interaction zone. Furthermore, lateral migration of shallow groundwater within the waste body would continue and subsequently discharge to the watercourse/drain.

New surface water drain could be constructed in close proximity to the existing watercourse/drain and the watercourse/drain could be left undisturbed.

The construction of a new surface water drain would prevent the interaction of clean surface water with contaminates entrained within the side walls of the waste body. Clean water from the surrounding environs would be redirected away from the existing watercourse/drain reducing the pollution potential. However, lateral migration of shallow groundwater within the waste body would continue and subsequently discharge to the existing watercourse/drain.

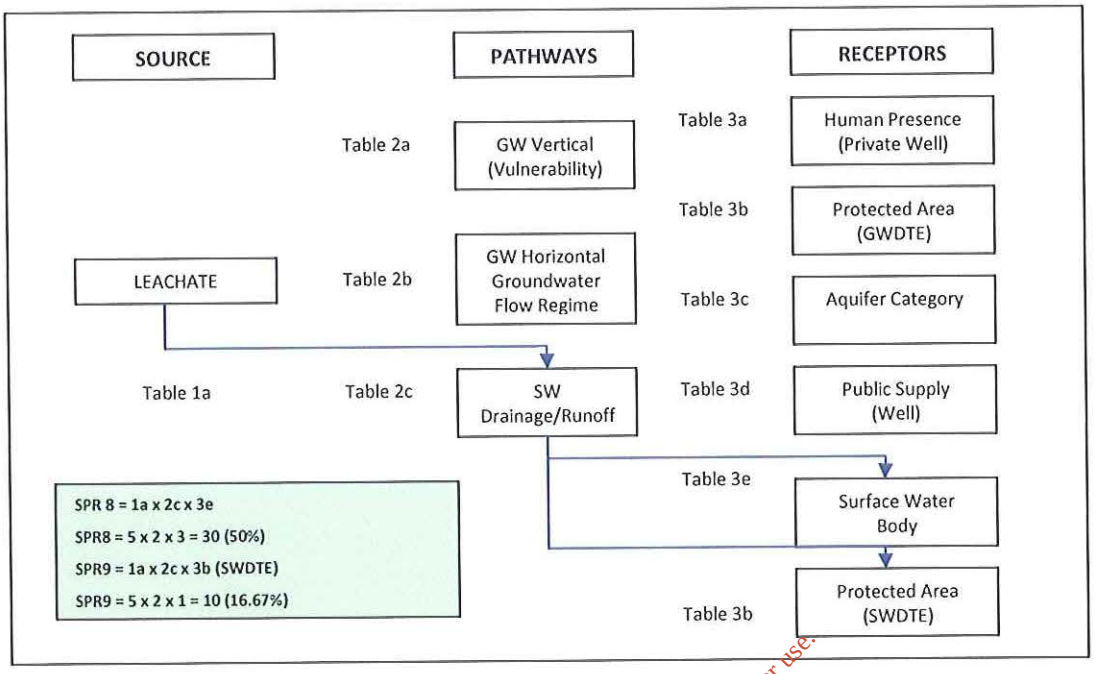
3.2.4.3 Recommended Remediation Measure

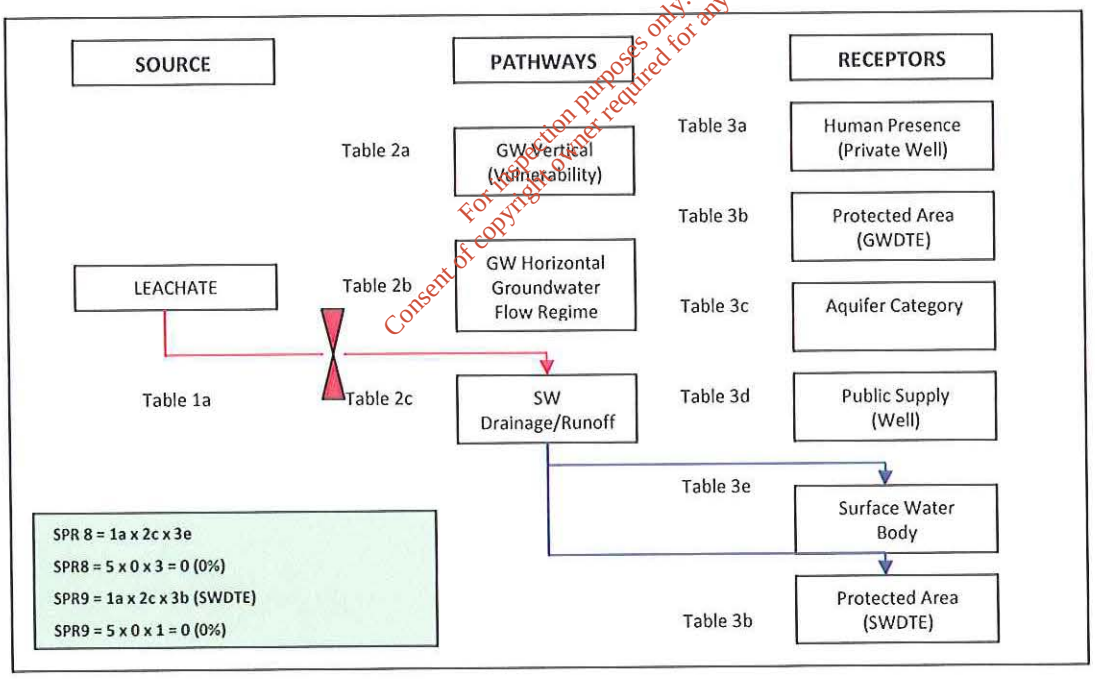
The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd recommends the removal of the substrate at the base of the watercourse and the disposal of same with a hazardous waste disposal company. This would be subject to appropriate testing for contaminants bound within the substrate prior to any works taking place. The volume of contaminated substrate requiring removal and disposal would be dependent on the substrate analysis results and the extent of the contamination. If the substrate proves negative for contamination the watercourse will still undergo excavation. These works will enhance drainage and break the interface between the landfill and the watercourse. The resultant water arising from the works would be passed through a full retention separator (in the event of any oily residues) and be discharged to nearby watercourse/drain. The discharge of the water would be dependent on a full schedule of testing being carried out prior to discharge as per the EPA landfill monitoring requirements. The volume of contaminated substrate requiring removal and disposal would be dependent on the substrate analysis results.

3.2.4.4 SPR Linkage Diagram

See diagram 4 showing the SPR Linkage prior and post remediation and highlighting the break in the linkage by the removal of the substrate.

Diagram 4 – SPR Linkage Diagram showing the break in the linkage by the removal of the substrate





3.2.4.5 Timescale for Completion of Works

The guesstimated timescale for the removal of the substrate and the re-engineering of the watercourse is 2-4 weeks. The aforesaid timescale would be dependent on resources available, weather conditions and no unforeseen problems during the re-engineering works.

3.2.4.6 Evaluation of Works

Substrate testing will be carried out prior to excavation works commencing. Periodic sampling and testing of discharge water would also be undertaken to ensure no negative impacts on downstream water quality.

3.2.5 CHEMICAL AND BIOLOGICAL MONITORING

Prior to and during the course of the remediation works chemical monitoring will be carried out periodically on both surface and groundwater within the vicinity of the landfill. Surface water samples will be taken upstream, downstream and from the interaction zone of the watercourse/drain. Groundwater samples will be taken from boreholes installed up gradient and down gradient of the landfill. It is proposed to install 3 boreholes outside the waste body with one located up gradient of the site (GW1) and two located down gradient of the site (GW2 & GW3). A location map of the proposed ground water monitoring points can be seen in Appendix A - Drawing No. 10.198.026. Samples will be analysed for a range of organic and inorganic parameters as specified in the EPA Landfill Monitoring Manual with particular attention to contaminants detected within the trial holes. Biological assessment of the watercourse/drain will also take place in conjunction with chemical monitoring during the course of the remediation works.

Subsequent to the remediation of the site surface water samples will be taken quarterly coupled with biological assessment twice yearly (preferable in early spring and repeated in early autumn in order to get a representative data set). Groundwater samples will also be taken quarterly from all three monitoring points in conjunction with surface water samples. Please refer to table 8 and 9 below for parameters and sampling frequency.

Table 8: Baseline Monitoring Requirements for Mullagh Landfill

Monitoring Medium	Parameters	Monitoring Points	Frequency
Surface Water	Flow/level and composition.	Upstream, downstream & interaction zone.	Quarterly for the first 12 months
	Biological assessment.	At least three monitoring points in the main watercourse/drain adjacent to the landfill - Upstream, downstream & interaction zone.	Twice a year for the first 12 months
Groundwater	Level and composition.	GW1, GW2 & GW3	Quarterly for the first 12 months

Table 9: Parameters for Monitoring Surface Water and Groundwater at Mullagh Landfill

Monitoring / Parameter[1]	Surface Water	Groundwater
Fluid Level	✓	✓
Temperature	✓	✓
Dissolved oxygen	✓	✓
pH	✓	✓
Electrical conductivity	✓	✓
Ammonia (as N)	✓	✓
Total oxidised nitrogen (as N)	✓	✓
Biochemical oxygen demand	✓	-
Chemical oxygen demand	✓	-
Metals	✓	✓
Total alkalinity (as $CaCO_3$)	✓	✓
Sulphate	✓	✓
Chloride	✓	✓
Molybdate Reactive Phosphorus	✓	✓
Cyanide (Total)	✓	✓
Fluoride	✓	✓
Trace organic substances inclusive of Mineral Oil, EPA Etc.	✓	✓
Biological assessment	✓	-

3.2.6 CAPPING OF MULLAGH LANDFILL

3.2.6.1 Re- Grading of Landform

The re-grading of the landform is vital to the overall remediation of the site and will break the infiltration of rainfall into the waste body. This re-grading will take place with what ever combination of remediation options are carried out. The re-grading of the slopes of Mullagh landfill would have a positive effect on the following:

- Stability of the side slopes;
- Enhanced surface water drainage;
- Reduction in the infiltration of rainwater;
- General landscaping and scenic amenity.

The main aspect of the re-grading is to pull back the side slopes of the landfill to a slope not greater than 1 (v):2.5(h). The non-hazardous waste pulled from the sides will be relocated in void spaces created during the excavation works associated with the hazardous waste excavations.

Re-grading is also considered necessary in terms of the stability of the side slopes particularly along the Northeast face. The final landform must have watersheds which will direct surface water towards the surrounding surface water. The final contour plan for the waste, prior to capping will be agreed with the Environmental Protection Agency (EPA).

3.2.6.2 Capping

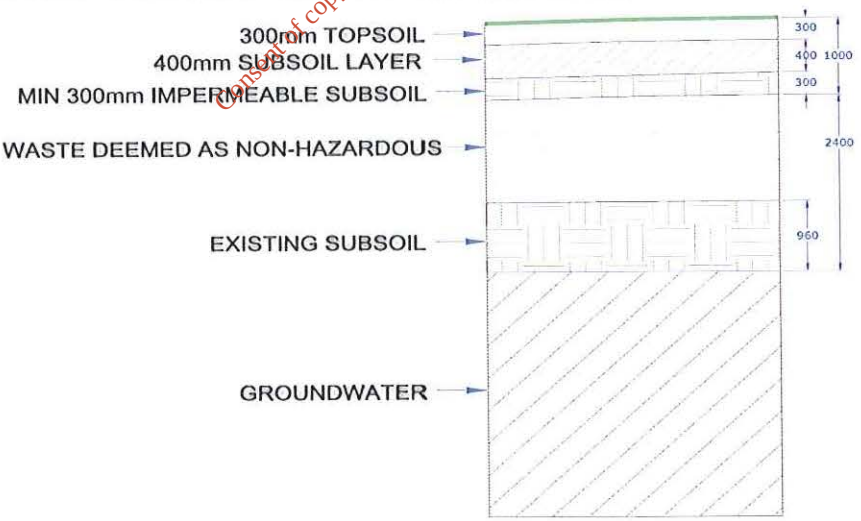
The main factors which influence the rate of infiltration of rainfall and hence the leachate generation is the configuration of the final top cover and associated topography, which will affect the site's run-off pattern and the amount of water percolating into the landfill.

Currently a layer of clayey soil of varying thickness and composition covers the landfill with waste protruding from same most notable on the north-western part of the site. The regarding of the site slopes between the landfill and watercourse coupled with the capping of the landfill will enhance surface water run-off and reduce the infiltration of rainwater into the waste body. The final cover will consists of clay with a low permeability thus enhancing run-off. The installation of a plastic liner in the final cover was not considered as the decomposition of residual waste within the landfill body may be reduced or cease altogether if moisture is prevented from entering the landfill.

Capping of the landfill with a suitable capping layer will result in a significant reduction in the amount of leachate generated within the site whilst allowing sufficient moisture to penetrate in order to maintain the decomposition process.

1) 300mm topsoil layer for grass and other vegetation.
2) 400mm thick low permeable clayey soil layer;
3) 300mm thick subsoil layer;

FIGURE 1: DIAGRAM SHOWING A TYPICAL CROSS SECTION OF THE CAPPING LAYER ON SITE.



Drawing No 10-198-012 shows cross section through the site showing the capping layers, see Appendix A.

Leachate generation would be reduced once the remediation measures are put in place. It is recommended to extend the capping layer across the surface and down the side slopes of the landfill. Where the base of the slope coincides with the edge of the surface water ditch, e.g. along the Northeastern side of the site, the capping should be extended down the Inner face of the ditch. The final capping layer could have a dome shape to aid surface water drainage.

3.2.6.3 Low Permeability layer

The main function of this layer is the control of leachate generation by minimising the infiltration of water into the underlying waste. This layer should consist of a material which can be compacted to a suitably low hydraulic conductivity which prevents most, but not all, of the moisture infiltrating into the waste.

The proposed capping should consist of a soil placed and compacted to permeability not greater than 1×10^{-9} m/s. To achieve these criteria, a clayey soil with the following characteristics is likely to be required.

- Liquid Limit (LL) <90
- Plasticity Index (PI) < 65
- % Clay >10
- Casagrande Classification above 'A' line
- Maximum particle size 75mm

Generally low permeability for compacted soils is achieved at moisture contents wet of optimum. Laboratory testing would need to be carried out on any proposed clay source prior to its use in the capping.

3.2.6.4 Subsoil

In addition to the low permeability layer a 400mm subsoil layer would be required across the capping layer in order to protect the low permeability layer and to help support vegetation. A loamy and relatively stone-free soil could be used for this layer.

3.2.6.5 Topsoil or Similar Layer

This layer is necessary to provide a foundation into which grass and any other vegetation might be planted. The topsoil or similar product should be uniform and have a minimum slope of 1 to 30 prevent surface water ponding. The topsoil should be thick enough to:

- Accommodate root systems;
- Provide water holding capacity to attenuate moisture from rainfall and to vegetation through dry periods;
- Allow for long term erosive losses;
- Prevent desiccation and freezing of the barrier layer.

A 200mm to 300mm covering of this material would be provided over the capping layer to give adequate depth for structure to develop.

3.2.6.6 Tree Planting and Final Landscaping

The landfill at Mullagh could be planted with a suitable mix of trees to ensure the establishment of a good sustained vegetative cover and aid the integration of the landfill into the landscape.

Tree planting have the following advantages for the site:

- It reduces soil erosion by establishing ground cover ;
- It reduces water infiltration on capped site and reduces discharge to watercourse/drain ;
- Helps to break the SPR Linkage 8;
- Improves visual appearance;

All tree and shrub planting should be carried out, in accordance with EPA guidelines for Landfill Restoration and Aftercare.

There are many factors to be considered when planting tree and shrub such as:

- Timing of tree and shrub planting;
- Method of tree and shrub planting;
- Tree and shrub suitability i.e. trees for 2m wide screening belt along road to front of the site;
- Soil suitability;
- Maintenance;
- Cost

The following is a list of trees which should be used as part of the landscaping scheme.

Table 10: Tall/Medium trees to be planted on site as part of the landscaping scheme

No.	Species	Height at year 20(m)	Remarks
1	Silver birch * *Betula pendula*	9	Fast growing, useful nurse crop, tolerates low fertility
2	Common alder * *Alnus glutinosa*	8	Nitrogen fixing, grows well in damp areas, good for wildlife
3	Sycamore *Acer pseudoplatanus*	8	Tolerant to exposure and air pollution, good for wildlife
4	Scots pine * *Pinus sylvestris (conifer)*	7	Visually attractive tree, grows well on poor exposed sites

Table 11: Small trees to be planted on site as part of the landscaping scheme

No.	Species	Height at year 20(m)	Remarks
5	Holly* *Illex aquifolium*	3	Good for wildlife and screening
6	Hawthorn * *Crataegus monogyna*	4	Commonly found in hedgerows, attractive tree with white blooms in the spring and deep red haws in autumn
7	Rowan * (mountain ash) *Sorbus aucuparia*	6	Hardy tree suitable for exposed site, good for wildlife
8	Goat willow *Salix caprea*	4	Associated with damp conditions

Table 12: Tall/Medium and Small trees to be planted on site as part of the landscaping scheme

No.	Species	Height at year 20(m)	Remarks
1	Aspen * *Populus tremula*	8	Grows well on poorer soils, suckers readily and tends to form groves of trees
2	Common Whitebeam* *Sorbus aria*	6	Tolerant of exposed and coastal sites, attractive amenity tree
3	Green alder *Alnus viridis*	2	
4	European larch *Larix decidua*	8	High amenity and wildlife value

Trees suitable for central area of the Landfill site (* indicates native species)

3.2.7 SURFACE WATER CONTROL & MANAGEMENT

3.2.7.1 EXISTING SITUATION

The landfill is currently capped with a thin layer of soil with precipitation freely entering the waste body. There is poor water run-off from the surface of the waste body with precipitation entering the landfill, being retarded by the underlying peat layer and migrating laterally to the watercourse/drain on the North-eastern aspect of the landfill. The discharge from the waste body is collected in an open perimeter watercourse/drain which flows Northeast to Southwest. The gradients within the watercourse/drain are minimal and thus flow within the watercourse/drain is limited during periods of low precipitation. The area northwest of the site is predominately bogland with low flow and stagnation also evident.

3.2.7.2 RECOMMENDED CONTROL OF SURFACE WATER DRAINAGE

The capping and regarding of the landfill will reduce the infiltration of precipitation into the waste body and promote surface water run-off and drainage to the watercourse/drain on the North-eastern aspect of the landfill. This will prevent the interaction of clean precipitation with the waste body, minimise the generation of leachate and limit the recharge of shallow groundwater flow. Furthermore, the installation of a drainage channel upslope of the landfill and redirecting same to the watercourse/drain on the North-eastern aspect of the landfill will minimise leachate generation shallow groundwater recharge within the landfill itself. The excavation of the watercourse/drain will also break the interaction interface between the landfill and watercourse/drain which is immediate to the site and will increase the surface water flow characteristics of the watercourse/drain. These measures combined will control the ingress of surface water and limit any possible interaction with the waste body thus breaking the source-pathway-receptor (SPR) linkage as identified in the Tier 2 Environmental Risk Assessment. Surface water will be monitored over time to ensure that there is no interaction between the waste body and surface water. This monitoring will check whether SPR linkage No.8 has been broken and ensure that the works carried out were effective.

3.3 SETTLEMENT

The final post settlement levels and contours of a landfill must be taken into account. This is to predict the amount of settlement that will occur and to ensure that this takes place as evenly as possible across the site. The rate and degree of settlement occurring at a landfill will always be site specific and will be influenced by the site conditions, landfill practices, types of waste deposited and the effects of the mechanical and biochemical processes. Settlement values of between 10 and 25 % of the depth of the landfill can be expected.

3.4 FENCING

The existing fence and gate at the entrance to the site are adequate, however the fence and gate may have to be taken down to facilitate the remediation of the landfill and the capping process. It is recommended to reinstall all fences and gates at the end of the remediation.

3.5 TIMESCALE FOR COMPLETION OF WORKS

From investigations carried out to date and the remediation's measures proposed for the Landfill, an approximate estimate on the time scale for completion of works is 24 months. The anticipated timescale for works will depend on resources available, weather conditions and no unforeseen events or problems being encountered e.g. greater quantities of hazardous waste, contaminated soil and groundwater than first estimated.

4.0 SUMMARY OF REMEDATION MEASURES

The Tier 2 Risk Assessment process resulted in the risk rating for the historic landfill remaining as **Moderate Risk.** SPR Linkage number 8 has been proven and thus risk rating assigned accordingly as **Moderate**.

Subject to appropriate remediation measures as outlined previously, been adhered to the risk rating for Mullagh historic landfill would be reduced from a Moderate Risk to a Low Risk site as a number of SPR linkages would have changed:

- SPR1 would change from a linkage score of 25.00 to 15.0;
- SPR2 would change from a linkage score of 8.33 to 5.00;
- **SPR8 WOULD CHANGE FROM A LINKAGE SCORE OF 50.00 TO 0.00;**
- SPR9 would change from a linkage score of 16.67 to 0.00;

THE REMEDIATION MEASURES AS OUTLINED WOULD BREAK SPR LINKAGE NO. 8. BY

- Removal of Hazardous wastes from the site and disposal at an approved facility;
- Removal of contaminated soils from the site and disposal at an approved facility;
- Removal of contaminated groundwater from the site and disposal at an approved facility;
- Remediation of existing groundwater on site which is deemed to have mineral oil contamination only;
- Excavation and disposal of the contaminated soil at the base of the watercourse/drain at an approved facility;
- Cleaning of watercourse/drain and re-engineering interface;
- Installation of an interceptor drain upslope of the landfill;
- Capping of the landfill which reduces and /or eliminates infiltration of rainwater and the mobilisation of residual contaminants (if any);
- Tree plantation and landscaping of the site to minimise reduce rainfall infiltration and leachate generation.

THE CHANGE IN THE LINKAGE SCORES AFTER REMEDIATION WORKS WOULD CHANGE THE OVERALL RISK RATING OF THE SITE WHICH IS CURRENTLY MODERATE RISK TO LOW RISK.

4.1 EVALUATION OF WORKS

The effectiveness of works carried out will be closely recorded in the time frame after completion of remediation and removal works. This will be achieved through a comprehensive schedule of surface and groundwater, chemical and biological monitoring. Results will be documented and comparisons drawn from prior sampling at the site to evaluate effectiveness of removal of the hazardous waste, contaminated soil and groundwater. The proposed parameters and frequency of the monitoring programme can be seen in Table 15 and Table 16 of the Tier 3 assessment.

5.0 SPR LINKAGES AFTER REMEDIATION WORKS CARRIED OUT

Subject to Remediation works carried out on site as detailed in option A of the Tier 3 Assessment Report the following SPR Linkages would change.

Table 13: SPR Linkages If Remediation Works Carried Out On Site As detailed per Option A in the Tier 3 Environmental Risk Assessment Report

Risk Equation	SPR Values	Max Score	Linkages	Normalised Scores (%)
***SPR 1 = 1a x (2a + 2b + 2c) x 3e**	**45**	**300**	**Leachate → Surface Water**	**15**
***SPR 2 = 1a x (2a + 2b + 2c) x 3b**	**15**	**300**	**Leachate → SWDTE**	**5**
SPR 3 = 1a x (2a + 2b) x 3a	30	240	Leachate → human Presence	12.5
SPR 4 = 1a x (2a + 2b) x 3b	15	240	Leachate → GWDTE	6.25
SPR 5 = 1a x (2a + 2b) x 3c	15	400	Leachate → Aquifer	3.75
SPR 6 = 1a x (2a + 2b) x 3d	0	560	Leachate → Surface Water	0.00
SPR 7 = 1a x (2a + 2b) x 3e	45	240	Leachate → SWDTE	18.75
***SPR 8 = 1a x 2c x 3e**	**0**	**60**	**Leachate → Surface Water**	**0.00**
***SPR 9 = 1a x 2c x 3b**	**0**	**60**	**Leachate → SWDTE**	**0.00**
SPR 10 = 1b x 2d x 3f	7.5	150	Landfill Gas → Human Presence	5.00
SPR 11 = 1b x 2e x 3f	0	350	Landfill Gas → Human Presence	0.00

Risk Classification	Score Range
High Risk (Class A)	**Greater than or equal to 70% for any individual SPR linkage**
Moderate Risk (Class B)	**Between 40% and 70% for any individual SPR linkage**
Low Risk (Class C)	**Less than or equal to 40% for any individual SPR linkage**

Overall Risk	Low Risk (Class C)

6.0 SUMMARY OF IMPACT OF REMEDIATION MEASURES AND POTENTIAL RISKS

		RISKS	
No.	**Remediation Measure**	**Positive**	**Negative**
3.2.1	Removal of Hazardous Waste	- Source of contamination has been eliminated and SPR linkage will be broken - Prevent further leaching of Hazardous contaminants.	Possible mobilisation of contaminant that could reach Surface and/or Groundwater.
3.2.2	Remediation/Removal of Contaminated Soil	- Areas of soil contaminated with hazardous waste have been removed thus breaking the SPR linkage. - Prevent further leaching of Hazardous contaminants.	- Disturbance of the soil may mobilise contaminants that may have been previously bound within the soil.
3.2.3	Remediation/Removal of Contaminated Ground water	- Prevent/reduce the risk of unaffected groundwater being polluted. - Prevent the mobilisation of contaminants beyond the affected areas.	- Removal of this groundwater could cause a cone of depression drawing more ground water to the area that was previously unaffected by contamination
3.2.4	Remediation/Removal of contaminated substrate from base of watercourse/drain.	- Source of contamination has been eliminated. - Landfill/watercourse interface re-engineered thus preventing interaction. - Prevent contamination of clean surface water entering the drain after remediation works.	- Disturbance of the substrate could cause mobilisation of contaminants
3.2.5	Surface Water and Groundwater Monitoring	- Monitoring will provide data on the effects, if any that remediation works may have on surface and groundwater quality. Corrective/preventative measures can then be taken if deemed necessary	No Negative effect
	Biological Monitoring of Surface Water	- Monitoring will provide data on the effects, if any that remediation works may have on surface and groundwater quality. Corrective/preventative measures can then be taken if deemed necessary	No Negative effect
3.2.6	Capping of Mullagh Landfill	- Prevent/significantly reduce infiltration of rainwater to the remaining waste body - Improve the visual appearance of the remediated landfill area.	- Disturbance of the waste may create hazardous airborne particulates and impact negatively on workers and nearby residents.
3.2.7	Surface Water Control and Management	- Installation of additional surface water drain up-gradient of the landfill, preventing the ingress of uncontaminated surface water entering the remaining waste body.	No Negative effect

7.0 VERIFICATION/VALIDATION REPORT

7.1 GENERAL

Following completion of remediation works, Cavan County Council would be required to submit a verification/validation report to the appropriate body for approval. The verification report should provide confirmation that all measures outlined in the approved remediation strategy have been successfully completed, including where appropriate, validation testing. The report should include:

- An Environmental Record completed for the Excavation works on site.
- Validation sampling of any imported soils, including details of the source of material and appropriate analysis carried out by an approved Laboratory with a Quality Management System that has been designed to meet the requirements of BS EN ISO/IEC 17025 and MCERTS (Soil).
- Any monitoring results of tests carried out prior to and during remediation of the site;
- Photographic and other media records;
- Waste management and disposal documentation ('Duty of Care');
- Confirmation that the Environmental Risk Assessment objectives have been met;
- An Environmental/Engineering Company with appropriate Professional Indemnity Insurance shall oversee all works and approve the associated works on site.
- Final topographic survey to confirm slopes of capping layer and all remediation objectives achieved.

8.0 HEALTH & SAFETY

The remediation of the landfill will require consideration of a number of health and safety issues. Apart from the normal precautions required in any earthworks based construction project, the excavation of partially decomposed waste coupled with the removal of hazardous waste, soil and groundwater from the site must be considered and properly assessed. The excavation of hazardous waste must be overseen by an appropriately qualified environmental scientist/chemist to assist in the identification of hazardous material. Furthermore, prior to any remediation works taking place on site the appointed contractor shall carry out a full risk assessment of the site taking cognisance of the contaminants identified in the Tier 2 Risk Assessment. The health and safety plan generated from the aforementioned risk assessment shall be site specific and deal with the removal of the hazardous waste while safeguarding the Health and Safety of on site personnel.

Each Contractor to be employed in remediation of the site would have to be competency assessed by Cavan County Council Health and Safety Department and subsequently appointed. No works shall take place on the site until a risk assessment and health and safety plan is submitted and approved by Cavan County Council. All works shall be carried out in strict compliance with the Safety, Health and Welfare at Work Act, 2005 as amended.

9.0 PROPOSED OPTION B

9.1 GENERAL OBJECTIVES

Prior to the Tier 2 Risk Assessment the main waste type dumped at Mullagh Historic Landfill was believed to be municipal waste. However, following extensive investigations of the site it was established that parts of the site contained hazardous waste. Chemical analysis of soil and groundwater within the trial pits confirmed the presence of hazardous waste (refer to Section 2.2 Soil Analysis Results and Section 2.3 Groundwater (Trial Pits) Results). Trial holes 3, 6, 8, 11, 13 and 18 had parameters which exceeded the Dutch Intervention Values and would be deemed hazardous waste hotspots within the site. The proposed remediation 'Option B' considers leaving the waste in-stu and the undertaking of measures associated with this.

The remediation option of leaving the waste in-situ will have the following objective:-

- To prevent a greater pollution risk associated with the dig-out and removal of waste as proposed in 'Option A'.
- Isolate the source of pollution within the waste body and break SPR Linkage No. 8.
- To reduce the pollution risk associated with the site.
- To reduce the pollution risk to the nearby watercourse.
- To reduce the pollution risk to groundwater.
- To reduce the interaction of surface water within the waste body.
- To minimise the ingress of precipitation into the waste body and interaction of same within the waste body.
- To improve the overall appearance of the landfill.
- To provide suitable conditions for plant and vegetation growth.

9.2 PROPOSED REMEDIATION MEASURES

The proposed measures below have been considered in the context of Option B:-

- 9.2.1 – Installation of interceptor drain upslope of the historic landfill.
- 9.2.2 – Re-engineering of existing watercourse/drain.
- 9.2.3 – Capping of Mullagh Landfill.
- 9.2.4 – Chemical and Biological Monitoring.

9.2.1 INSTALLATION OF INTERCEPTOR DRAIN

The peat layer beneath the waste body is preventing the vertical migration of contaminants. Shallow lateral groundwater flow is the predominant pathway through the waste body with basal discharges to the watercourse/drain immediate to the site. During the Tier 2 investigations a high water table was noted on the north eastern aspect of the site especially in TH12, 13, 14, 15, 16, 17 and 18. This groundwater flow is actively interacting with the waste body/hazardous waste and leading to the contamination of shallow groundwater as proven by the chemical analysis carried out in the Tier 2 Risk Assessment (refer to Tier 2 Risk Assessment Report).

9.2.1.1 Impact of Remediation Measure

The main aim of the interceptor drain upslope of the historic landfill is to disrupt the shallow groundwater flow dynamics within the site. Shallow groundwater is currently entering the landfill on the north eastern aspect of the site. The installation of the interceptor drain will break the movement of groundwater into the site and ultimately lower the water table within the waste body. The volume of groundwater entering and interacting with the waste body would be reduced thus minimising the contamination of groundwater and subsequent basal discharges from the site.

However, the installation of an interceptor drain could disrupt the current hydraulic equilibrium on the site. Current shallow groundwater flow would be prevented from entering the waste body and the resultant reversal of groundwater dynamics could lead to the discharge of contaminated groundwater/leachate to the newly constructed interceptor drain.

9.2.1.2 Alternative Considered

The installation of sheet piling along the north eastern aspect of the landfill was considered as an alternative to an interceptor drain. The sheet piling would act as a barrier to the movement of shallow groundwater flow minimising the interaction of groundwater with the waste body. However, the use of sheet piling would not guarantee the complete isolation of groundwater from the waste body. Furthermore, sheet pilling could lead to the puncture of the peat layer thus enabling the vertical migration of contaminates.

9.2.1.3 Recommended Remediation Measure

The main aim of the interceptor drain would be to prevent the ingress of shallow groundwater and the interaction of same with the waste body. The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd would recommend the installation of the interceptor drain upslope of the landfill but the said works could not be carried out in isolation. The groundwater within the waste body would require removal and disposal by vacuum tanker. This would prevent the reversal of the groundwater dynamics and the release of contaminates thus minimising the impact on the receptors immediate to the site.

9.2.1.4 SPR Linkage Diagram

The installation of the interceptor drain would isolate shallow groundwater flow within the waste body and prevent the interaction of groundwater with hazardous waste. The SPR linkage would be disrupted thus minimising the flow of contaminates to the nearby watercourse/drain. However, the hazardous waste would still be in-stu and the complete isolation of shallow groundwater flow and subsequent basal discharges from the site cannot be guaranteed.

9.2.1.5 Timescale for Completion of Works

The guesstimated timescale for the installation of the interceptor drain would be 2-3 weeks. The aforesaid timescale would be dependent on resources available, weather conditions and no unforeseen problems during the engineering works.

9.2.1.6 Evaluation of Works

Periodic sampling and testing of the interceptor drain and nearby watercourse/drain would be undertaken to ensure no negative impacts on downstream water quality. The sample result would indicate the success of the works and whether the pathway linkage between the hazardous waste and watercourse/drain has been broken

9.2.2 RE-ENGINEERING OF EXISTING WATERCOURSE/DRAIN

The watercourse/drain immediate to the site is actively interacting with the waste body and impacting negatively on surface water quality. The biological analysis indicated long term pollution effects on the watercourse/drain from the waste body and this was validated by the Q2 biological assessment rating assigned along the interaction zone.

9.2.2.1 Impact of Remediation Measure

The re-engineering of the existing watercourse/drain would prevent the interaction of surface water with the waste body. The re-engineering works would create a physical barrier between the waste body and watercourse/drain disrupting the pathway for contaminants and isolating the receptor. However, the re-engineering works could result in the release of contaminants bound within the substrate at the base of the watercourse/drain and impact negatively on water quality downstream of the site.

9.2.2.2 Alternative Considered

Watercourse/drain could be left undisturbed to prevent the mobilisation of possible contaminants

The watercourse/drain could be left undisturbed thus preventing the mobilisation and release of contaminates. However, the intermittent release of contaminates may still persist and lead to long term pollution effects within the watercourse/drain interaction zone. Furthermore, the complete cessation of shallow groundwater flow and surface water infiltration within the waste body cannot be guaranteed and further discharges to the watercourse/drain would be expected.

New surface water drain could be constructed in close proximity to the existing watercourse/drain and the watercourse/drain could be left undisturbed.

The construction of a new surface water drain would prevent the interaction of clean surface water with contaminates entrained within the side walls of the waste body. Clean water from the surrounding environs would be re-directed away from the existing watercourse/drain reducing the pollution potential. However, lateral migration of shallow groundwater flow coupled with surface water infiltration within the waste body would continue and subsequently discharge to the existing watercourse/drain.

9.2.2.3 Recommended Remediation Measure

The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental would recommend the re-engineering of the existing watercourse with the aim of isolating the watercourse/drain from the waste body. This may be achieved by the installation of an impermeable liner between the waste body and watercourse/drain or the piping of the watercourse/drain.

9.2.2.4 SPR Linkage Diagram

The complete cessation of shallow groundwater flow and surface water infiltration within the waste body cannot be guaranteed. The hazardous waste would still be in-stu and further discharge from the waste body would continue. The pathway for contaminants to reach the watercourse/drain would be disrupted but discharges from the waste body would still persist and would require ongoing management.

9.2.2.5 Timescale for Completion of Works

The guesstimated timescale for the re-engineering of the watercourse/drain would be 2-4 weeks. The aforesaid timescale would be dependent on resources available, weather conditions and no unforeseen problems during the re-engineering works.

9.2.2.6 Evaluation of Works

Periodic sampling and testing of the watercourse/drain immediate to the waste body would be undertaken to ensure no negative impacts on downstream water quality. The sample result would indicate the success of the works and whether the installation of the physical barrier has mitigated the impacts of the waste body on the watercourse/drain.

9.2.3 CAPPING OF MULLAGH LANDFILL

Mullagh historic landfill is currently covered with a layer of clayey soil of varying thickness and composition with waste protruding from the waste body on the north western aspect of the site. The capping of the landfill will enhance surface water run-off and reduce the infiltration of surface water into the waste body. This will ultimately reduce the generation of leachate within the waste body and the subsequent discharge of same from the waste body. However, the capping layer will not eliminate the infiltration of surface water into the waste body. The interaction of the surface water with hazardous waste will continue (although limited) and result in discharges from the waste body. The details pertaining to the construction and technical specifications of the capping layer has been previously discussed in Section 3.2.6 of the above document and therefore no further comment will be made in this section.

9.2.4 CHEMICAL AND BIOLOGICAL MONITORING

Chemical and biological monitoring will ultimately determine whether the remediation options outlined above have been successful at breaking the SPR Linkage. Prior to and during the course of the remediation works chemical monitoring will be carried out periodically on both surface and groundwater within the vicinity of the landfill. Surface water samples will be taken upstream, downstream and from the interaction zone of the watercourse/drain. Groundwater samples will be taken from boreholes installed up gradient and down gradient of the landfill. It is proposed to install 3 boreholes outside the waste body with one located up gradient of the site (GW1) and two located down gradient of the site (GW2 & GW3). A location map of the proposed ground water monitoring points can be seen in Appendix A - Drawing No. 10.198.026. Samples will be analysed for a range of organic and inorganic parameters as specified in the EPA Landfill Monitoring Manual with particular attention to contaminants detected within the trial holes. Biological assessment of the watercourse/drain will also take place in conjunction with chemical monitoring during the course of the remediation works. Subsequent to the remediation works surface water samples will be taken quarterly coupled with biological assessment twice yearly (preferable in early spring and repeated in early autumn in order to get a representative data set). Groundwater samples will also be taken quarterly from all three monitoring points in conjunction with surface water samples. Please refer to Section 3.2.5 table 8 and 9 for parameters and sampling frequency.

10.0 SUMMARY OF REMEDIATION MEASURES

The Tier 2 Risk Assessment process resulted in the risk rating for the historic landfill remaining as **Moderate Risk.** SPR Linkage number 8 has been proven and thus risk rating assigned accordingly as **Moderate**.

The main aim of the remediation measures is to break SPR linkage No. 8 as outlined in the Tier 2 Risk Assessment. The application of the remediation measures outlined in option B would not significantly change the SPR Linkage for the following reasons:-

- The installation of an interceptor drain upslope of the waste body could minimise the ingress of shallow groundwater flow into the waste body. However, the complete isolation of groundwater cannot be guaranteed by this measure. Furthermore, hazardous waste will still be in-stu and intermittent discharges from the waste body would be expected. The watercourse/drain immediate to the waste body would still be at risk and the connection between both entities would still exist.

- The re-engineering of the existing watercourse/drain could potentially break the connection between the waste body and the watercourse/drain. However, the complete cessation of shallow groundwater flow and surface water infiltration into the waste body cannot be guaranteed. Hazardous waste will be left in-stu and any interactions between groundwater flow and infiltration water could result in contaminated discharges from the site thus posing a risk to the nearby watercourse/drain. Even though the existing watercourse maybe isolated by the use of liners and/or piping the resultant basal discharge from the waste body will still exist and could be potentially hazardous.

- The capping of the landfill would significantly reduce the infiltration of surface water into the waste body and thus minimise the generation of leachate. However, capping in itself cannot eliminate the infiltration of surface water into the waste body. The interaction of infiltrated water with hazardous waste left in-stu will still continue (although limited) and could result in potentially hazardous discharges from the waste body.

THE REMEDIATION WORKS WOULD NOT CHANGE THE OVERALL RISK RANKING FOR THE SITE WHICH IS CURRENTLY MODERATE RISK.

11.0 SPR LINKAGES AFTER REMEDIATION WORKS CARRIED OUT

The remediation works outlined in option B of the Tier 3 Assessment Report would not change the overall risk ranking for the site which is currently moderate risk.

Table 14: SPR Linkages if Remediation Works Carried Out On Site As detailed In Option B of the Tier 3 Environmental Risk Assessment Report

Risk Equation	SPR Values	Max Score	Linkages	Normalised Scores (%)
***SPR 1 = 1a x (2a + 2b + 2c) x 3e**	**75**	**300**	**Leachate → Surface Water**	**25.00**
***SPR 2 = 1a x (2a + 2b + 2c) x 3b**	**25**	**300**	**Leachate → SWDTE**	**8.33**
SPR 3 = 1a x (2a + 2b) x 3a	30	240	Leachate → human Presence	12.5
SPR 4 = 1a x (2a + 2b) x 3b	15	240	Leachate → GWDTE	6.25
SPR 5 = 1a x (2a + 2b) x 3c	15	400	Leachate → Aquifer	3.75
SPR 6 = 1a x (2a + 2b) x 3d	0	560	Leachate → Surface Water	0.00
SPR 7 = 1a x (2a + 2b) x 3e	45	240	Leachate → SWDTE	18.75
***SPR 8 = 1a x 2c x 3e**	**30**	**60**	**Leachate → Surface Water**	**50.00**
***SPR 9 = 1a x 2c x 3b**	**10**	**60**	**Leachate → SWDTE**	**16.67**
SPR 10 = 1b x 2d x 3f	7.5	150	Landfill Gas → Human Presence	5.00
SPR 11 = 1b x 2e x 3f	0	250	Landfill Gas → Human Presence	0.00

Risk Classification	Score Range
High Risk (Class A)	Greater than or equal to 70% for any individual SPR linkage
Moderate Risk (Class B)	Between 40% and 70% for any individual SPR linkage
Low Risk (Class C)	Less than or equal to 40% for any individual SPR linkage

Overall Risk	Moderate Risk (Class B)

12.0 RECOMMENDED REMEDIATION OPTION

The Waste Management Section of Cavan County Council in conjunction with Traynor Environmental Ltd recommends **Option A** for the remediation of Mullagh Historic Landfill. The proposed remediation measures outlined in Option A will eliminate the source of contamination, disrupt the contamination pathways and isolate the receptor (watercourse/drain) from the waste body. SPR Linkage No. 8 would be broken and the required environmental outcome would be achieved.